Development of a nanometric range precision Limb sensor for an Image Stabilization System for the SO/PHI instrument

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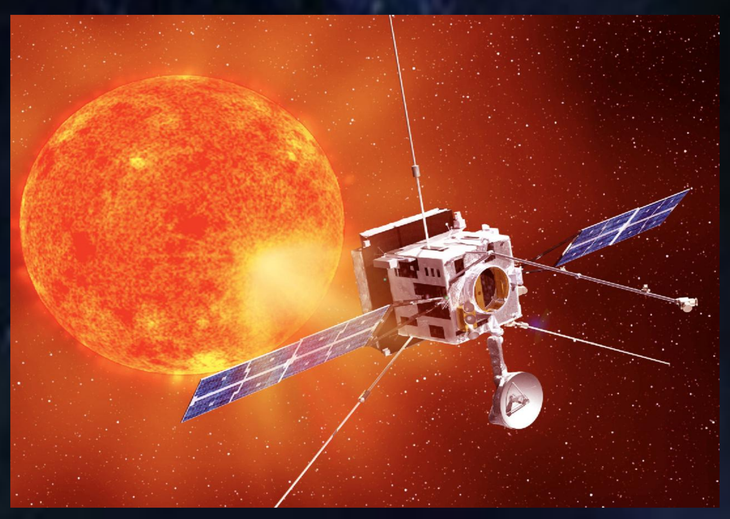
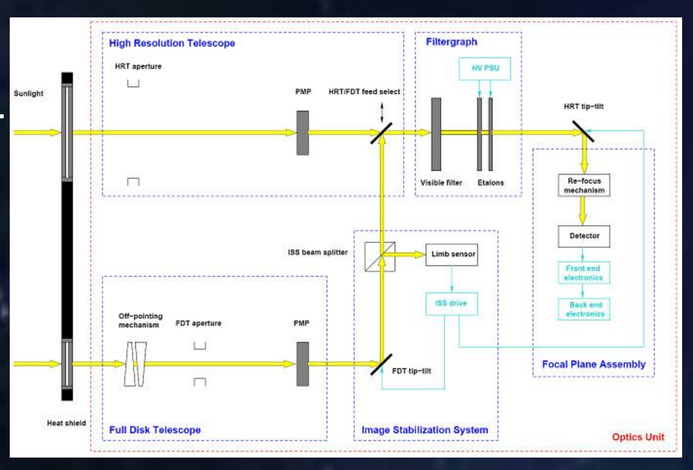
Introduction

The Solar Orbiter mission, developed by ESA, consists on a sun-observing satellite with different scientific instruments.



One of these instruments is called PHI (Polarimetric and Helioseismic Imager).

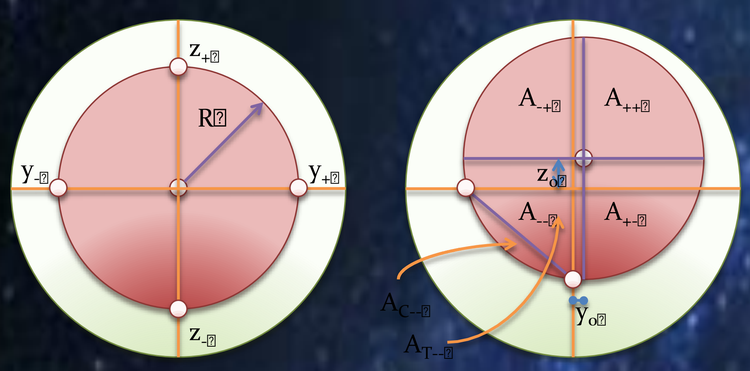
One of the objectives of the PHI Instrument is to generate high precision spectropolarigrams. An ISS (Image Stability System) is used to achieve this precision.



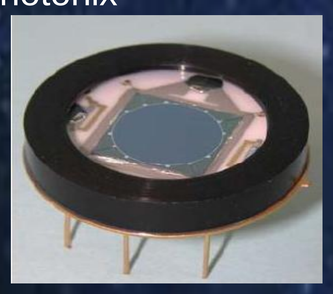
Method

A solution based on a Limb sensor was first adopted for the ISS.

This solution consists of a four-quadrant photodiode. When sun image is off the center, different signals are measured at each quadrant.

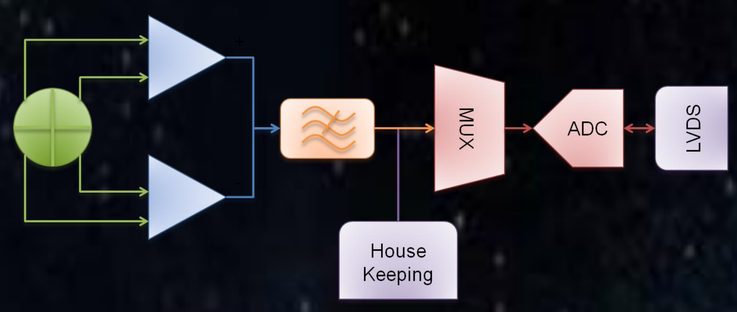


The sensor is the SD380-23-21-251 from Advanced Photonix



Solution

Quasi-analog solution:



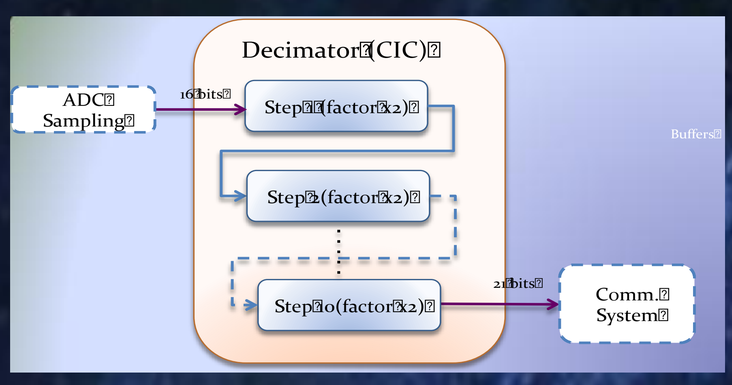
Resulting signals are:

$$\begin{cases} \Delta_y = \Delta_+ + \Delta_- = 2R(y_0 + z_0) + 2R(y_0 - z_0) = 4Ry_0 \\ \Delta_z = \Delta_+ - \Delta_- = 2R(y_0 + z_0) - 2R(y_0 - z_0) = 4Rz_0 \end{cases}$$

Δ_+ and Δ_- are the difference of signals between two counter-opposed quarters.

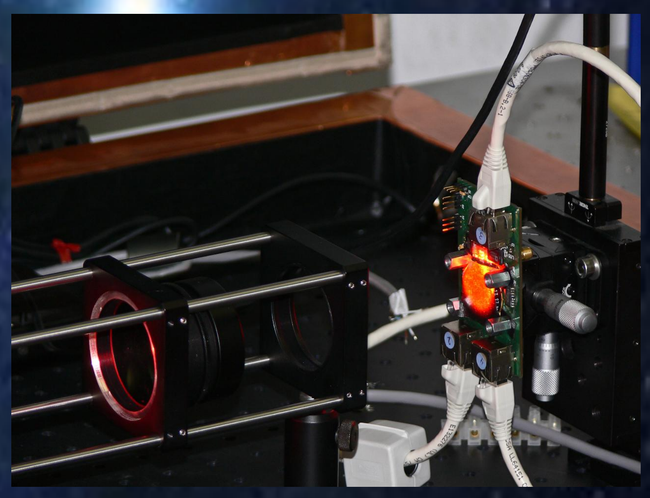
20 bits of resolution for the ADC is needed for our precision, but no space qualified ADC exists with such a performance.

Solution: Oversampling using Comb filters.



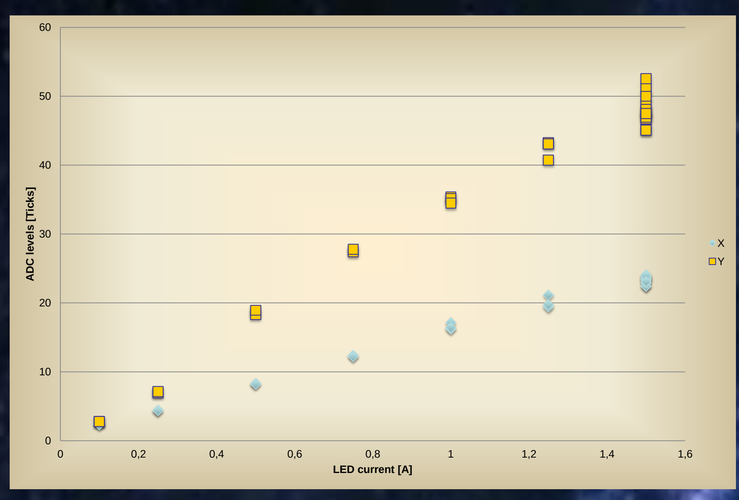
Test setup

Test setup consists on a damped optical table, where the sensor board is positioned accurately by the control of two motors. A sun image is generated by an optical system. Finally, this system is inside a Faraday cage.

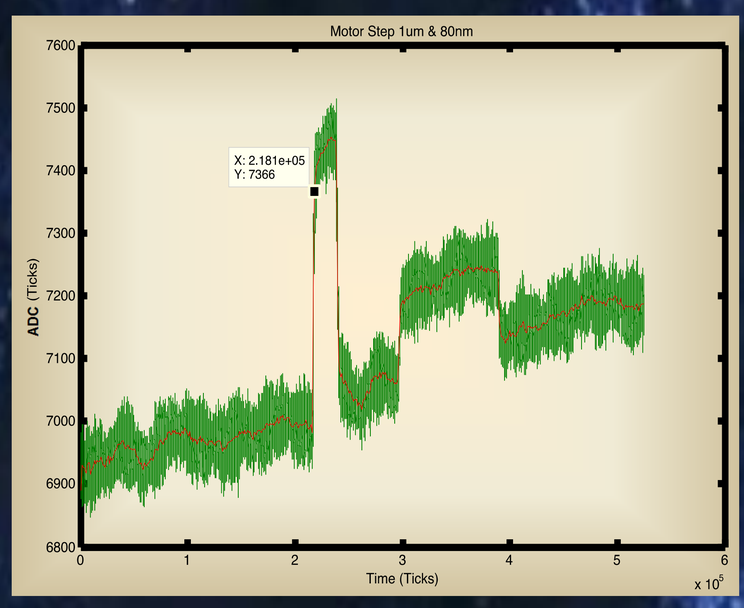


Results

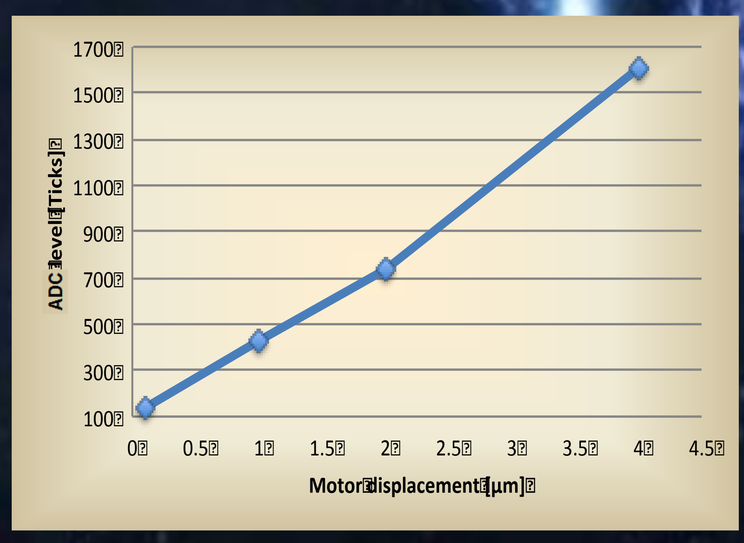
Noise analysis for x and y axis under lighted conditions:



Sensor response with respect to the motors action:



Measurement with decimated values:



Conclusions

A 20 bit image resolution has been achieved by using a 16bit resolution ADC and oversampling techniques. This provides a precision below the 80nm range.

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